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Device and process for reinforcing bearing structures

The invention relates to a device for reinforcing bearing structures as claimed in patent claim 1 and a
5 corresponding process for this purpose as claimed in patent claim 10.

In the restoration of bearing structures on existing constructions, the problem often arises that the
10 bearing structure is intended to be adapted to new load situations in excess of the former dimensioning. In order to avoid fully replacing the bearing structure in such cases, methods and devices have been found for reinforcing such existing bearing structures. Such
15 bearing structures can be bridges, traditionally built brick walls or, for example, reinforced concrete walls or beams, wooden, plastic or steel beams.

The use of retrofitted steel plates to reinforce such
20 bearing structures has been known for some time. The steel plates, i.e. steel band plates or steel sheets, are in this case stuck onto one or two sides of the bearing structure, preferably onto those sides of the bearing structure which are subjected to tensile load.
25 This process had the advantage of being able to be performed relatively speedily, but placed high demands upon the sticking, i.e. the preparation of the parts and of the adhesive surface. The sticking has to be performed under precisely defined conditions in order
30 to achieve the desired effect. Problems with this method arise, in particular, in the corrosion sphere, i.e. where open-air bearing structures are intended to be reinforced in this way, for example, bridge girders. Owing to the relatively high weight and the production
35 of such steel sheets, the maximum usable length is limited. Use in confined spaces may also be problematical for spatial reasons, if the rigid steel sheets cannot be conveyed into the appropriate space.

In "overhead" applications, moreover, the steel sheets have to be pressed against the reinforcing bearing structure until the adhesive sets, which likewise entails a great deal of effort.

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More recently, carbon sheets (CFRP sheets), too, are now being stuck onto the traction sides of the bearing structure and thus the load-bearing capacity of such structures is being subsequently enhanced through increased bearing resistance and ductility. An advantage with this are the cheap and simple application of such sheets, which have greater strength than the steel sheets, combined with far lighter weight, and are easier to mount. Likewise, the corrosion resistance is better, so that such reinforcements are also suitable for reinforcing open-air bearing structures. In this case, however, the end anchorage of the sheets, in particular, has so far proved problematical. In this sphere, specifically, there is a particularly high risk of the sheets becoming detached and there is the problem of force being transferred from the sheet end into the beam. A known solution for this consists in making in the beam a shallow-angled bore or wedge-shaped recess, into which the ends of the CFRP sheets are fitted and, where necessary, are pressed against the beam by means of clamps, loops, plates, etc. This, in itself, leads to improved detachment characteristics and better force transfer from the beam into the sheet.

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Traditionally, such CFRP sheets are stuck onto the beam without prestress, i.e. slack. A large part of the reinforcement potential of these sheets thus remains untapped, however, since they start to provide support only once the basic load has been exceeded, i.e. under strain from the actual live load. In order to make better use of the sheets, the idea has now emerged of sticking them onto the beam in a prestressed state. A known solution provides in this regard that short steel

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plates are glued on the ends of the CFRP sheets on both sides, the steel plates are then tensioned away from each other so that the CFRP sheet is prestressed, and this prestressed arrangement is glued to the beam to be reinforced. Once the glue joint has dried, the sheets, at the ends, are pressed against the beam by means of plates, loops, etc. and then the ends cut off with the steel plates. This process is now very complex, however, nor can it be used in all applications. At present, the type of anchorage of the sheet ends which is described above has only limited suitability for prestressing at construction sites.

According to EP1007089, a reinforcement of bearing elements, such as, for example, concrete beams, by the use of CFRP sheets is known, these being split on the end side and being glued, wedged or held by friction-locking in the retaining slots in the termination elements at an angle to one another. The termination elements are glued, wedged or held in place by friction-locking on the traction side of the bearing element or embedded in a corresponding cutout in the bearing element with or without prestress.

An advantage with this solution is that considerable sheet anchorage forces can be produced with a short, compact end anchorage. Moreover, the force transfer can be realized even without adhesive (friction-locking).

A proven disadvantage is that the CFRP sheet is prefabricated in the factory or has to be cut to length in the factory. In addition, the splitting of the sheet is a tricky operation which calls for precision working.

The object of the present invention is to propose a device for reinforcing bearing structures which is space-saving and is particularly suitable for fitting on the spot, i.e. at the construction site, with or

without prestress, said fitting being quick and uncritical.

5 A further object consists in defining a corresponding process for this purpose.

According to the invention, this object is achieved with a device according to the wording of patent claim 1 and with a process according to the wording of patent
10 claims 10, 11 and 13. The invention is explained in greater detail below with reference to the drawings, in which:

Fig. 1 shows a diagrammatic representation of a device according to the invention having a
15 CFRP sheet and termination elements,

Fig. 2 shows a termination element according to the invention prior to the wedges being driven in, represented in section,

Fig. 3 shows an illustrative embodiment of a
20 termination element prior to the sleeve being forced onto the wedges and the CFRP sheet, represented in section.

Fig. 1 shows the diagrammatic representation of a
25 device according to the invention with CFRP sheet and termination elements.

A bearing structure 1 has on the top side two recesses 2, 2', which are designed to receive the termination
30 elements 3, 3'. A CFRP sheet 4 spans the bearing structure 1 and is pressed in place in the termination elements 3, 3'.

The recesses 2, 2' are generally milled or bored into
35 the bearing structure and generally have a cylindrical shape. Such an arrangement of the termination elements is space-saving and proves to be particularly advantageous. The CFRP sheet 4 can be wholly, or at

least partially, connected to the bearing structure by means of a layer of adhesive.

Fig. 2 shows a termination element according to the invention prior to the wedges being driven in, represented in section.

The CFRP sheet 4 lies in the center of a sleeve 5 and is held centrally in place by wedges 6, 6'. The wedges, which jut over the wider sleeve end, are represented in the position prior to them being driven in. When the wedges are driven in against the conically tapered end of the sleeve, the necessary transverse pressure upon the CFRP sheet is built up, so that this is jammed immovably in the sleeve (friction-locking). A known problem is for the CFRP sheet to slide away out of the sleeve, which is here effectively prevented according to the invention by coupling means 7, which are applied to the CFRP sheet 4 at least on one side, but preferably on both sides, and whereby the CFRP sheet, in the region of the sleeve 5, at least partially covers the latter.

The sleeve 5, the wedges 6, 6' and the coupling means 7 form the termination element 3.

The device according to the invention can be used with or without prestress, so that the termination element 3 is also referred to as the anchoring head or tensioning head.

The sleeve 5 consists of plastic, especially a fiber-reinforced plastic, of steel or some other high-strength material. It is conically configured, at least on the inner side, and has a substantially circular, an elliptical or a substantially square or rectangular inner cross section. The outer side of the sleeve can be freely chosen independently of the inner side,

namely, for example, to be of cylindrical, preferably, however, also conical configuration.

- 5 The wedges 6, 6' are made of plastic, especially a fiber-reinforced plastic, of steel or some other high-strength material, of ceramic or of aluminum, of mortar, concrete or casting compound. In the simplest case, they consist of two identical wedges. A division of the same is also, however, conceivable, in which
- 10 case, in a division into 2 x 2 wedges, for example, two find themselves on the top side and two on the bottom side of the CFRP sheet. A non-symmetrical division into, say, two and three wedges is also conceivable.
- 15 Even a single wedge can possibly be driven in, if the CFRP sheet is held centrally in place by a corresponding counterpart already fixedly connected to the sleeve.
- 20 On the other hand, a first of two wedges, for example, can be held in the sleeve in the end position with a contact adhesive, after which a single second wedge is driven in. This arrangement has the advantage, where accessibility is limited to one side, of nevertheless
- 25 imparting the necessary prestress with an appropriate prestressing device. This, in itself, marks a fundamental advantage of the device according to the invention.
- 30 The coupling means 7 consist of an adhesive, of an abrasive, such as, say, of a grain size of 0.1-1.0 mm, of a film provided with an abrasive, of a powder coating or a plasma coating and the like. They form a so-called bonding bridge between the CFRP sheet 4 and
- 35 the wedges 6, 6'. The coupling means 7 are not, however, necessarily located solely on the CFRP sheet. On the contrary, they can also be disposed on the inner side of the sleeve, to be precise over the whole of the surface area, in partial coverage, in paths disposed

the pull direction, or they are disposed helically around the pull direction. What is essential is that the friction parameter between the CFRP sheet and the wedges and, possibly, also to the sheet becomes large
5 and the necessary transverse pressure from the pressing-in of the wedges is permanently present.

The process according to the invention, in which the wedges are pressed in or driven in around the CFRP
10 sheet, is described later. The arrows on the wedges serve to indicate the press-in direction.

Fig. 3 shows an illustrative embodiment of a termination element prior to the sleeve being forced
15 onto the wedges and the CFRP sheet, represented in section.

The conically configured sleeve 5 has outer diameters of 50 mm and 65 mm. It has an oval cross section and a
20 110 mm length and 6.0 mm wall thickness. It consists of a carbon-fiber composite (CFRP). The CFRP sheet 4 has a cross section of 2.4 x 60 mm and is a carbon-fiber-reinforced plastic (Sika CARBODUR, Sika AG, CH-8048 Zurich). As the coupling means 7, a non-ageing abrasive
25 paper, coated on both sides, has been applied to both sides of the CFRP sheet 4 in the region of the sleeve. A coupling means between the wedges 6, 6' and the sleeve 5 has been dispensed with here. The two wedges 6, 6' are likewise made of a carbon-fiber-reinforced
30 plastic (CFRP). The wedges have been driven or pressed into the sleeve with a force of 200 kN. A tensioning head or termination element of this kind withstands test forces of at least 300 kN.

35 The mass of the sleeve may vary within a wide range, of course, though always in dependence on the predefined sheet cross section.

According to the invention, this illustrative embodiment constitutes an alternative process, in which the sleeve is forced onto the wedges and the CFRP sheet, as described later. The force-on direction is indicated by the arrows on the sleeve 5.

The process for reinforcing bearing structures by means of a device according to the invention is described below.

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The CFRP sheets are intended to be supplied on rolls to the construction site, cut to length there, and tensioned and anchored without splitting of the sheet ends.

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In a first step, recesses 2, 2' or cutouts are made in the bearing structure 1; i.e. these are dug out, milled, bored, etc. Into the recesses 2, 2' there are now fitted or inserted the so-called 'supports' of known type, which serve as force transfer elements and which are precisely positioned there.

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In a second step, the CFRP sheet 4 is threaded in or drawn in or introduced and positioned, to be precise, in sequence, through the first recess 2 and the first support, through the first termination element 3, around the bearing structure 1, through the second recess 2' and the second support, through the second termination element 3', until the CFRP sheet 4 juts over the latter.

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The CFRP sheets are generally supplied on rolls to the construction site and are drawn off there from a reel-off stand. Prefabricated CFRP sheets in U-shape may also possibly be used.

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In a third step, the coupling means 7 are applied to the CFRP sheet, to be precise in the region of the termination elements 3, 3'.

In a fourth step, the at least one wedge 6' of the second termination element 3' is pressed into the second sleeve 5', this being realized without pulling
5 on the CFRP sheet 4.

The CFRP sheet is next prestressed, which is realized with a prestressing apparatus located above the first termination element 3. A double-sided, simultaneous
10 tensioning at both ends of the CFRP sheet is also possible, in which case a prestressing apparatus is respectively located above each of the two termination elements 3, 3'. A prestress can also however be fully omitted.

15 In a fifth step, the at least one wedge 6 of the first termination element 3 is driven in or pressed in. Above the first termination element 3, the CFRP sheet is subsequently cut off. The process for reinforcing the
20 bearing structure is herewith concluded.

The CFRP sheet 4, which is disposed around the traction side of the bearing structure 1 to be reinforced, can be stuck at least partially on the latter.

25 An alternative process is obtained in maintenance of steps 1 to 3 and with modified steps 4 and 5 as follows:

30 In a fourth step, the second sleeve 5' is forced onto the at least one wedge 6' of the second termination element 3' and the CFRP sheet, this being realized without pulling on the CFRP sheet 4.

35 The CFRP sheet is next prestressed, which is realized with a prestressing apparatus located above the first termination element 3. This prestress can also be omitted.

In a fifth step, the first sleeve 5 is forced onto the at least one wedge 6 of the first termination element 3 with the CFRP sheet. Above the first termination element 3, the CFRP sheet is subsequently cut off. This
5 alternative process for reinforcing the bearing structure is herewith concluded.

A further alternative process is obtained in maintenance of steps 1 to 3 and with modified steps 4
10 and 5 as follows:

In a fourth step, the CFRP sheet 4 is prestressed, or 10-20% overstressed, the at least one wedge 6, 6' being found loosely introduced in the sleeve, but not yet
15 pressed in. Possible adhesives or holding devices hold the wedges stable in this position.

In a fifth step, the prestress is now partially slackened, the at least one wedge 6, 6' being drawn in or pressed in in self-wedging arrangement in the sleeve
20 5. The prestress which is ultimately necessary is herein maintained. The CFRP sheet 4 is subsequently cut off above the first termination element 3. This further alternative process for reinforcing the bearing
25 structure is herewith concluded.

Devices according to the invention are especially suitable for the restoration of concrete bearing structures, such as, for example, floors or bridge
30 girders. In addition, they can also be used for all known applications of traditional CFRP sheets, such as, for example, brickwork constructions, timber bearing structures, steel constructions and earthquake reinforcements. The simple prestressability allows the
35 strength characteristics of the CFRP sheets to be put to greater use. In addition, the prestress brings about a pre-pressing on the traction side of an existing bearing element, which is advantageous specifically in respect of bridge girders, for example.

The process is characterized by high economy and rapid fitting and the device is characterized by high flexibility in the manner in which it is arranged on
5 the bearing structures to be reinforced.